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Behind the Definition of Fuel Poverty: Understanding Differences between the Fuel Spend of Rural and Urban Homes

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The fuel poor are those households that must spend more than 10% of their income to sustain a reasonable heating regime. The measures for fuel poverty in Scotland depend on a fuel spend for modelled energy use patterns, while England and Wales have adopted a relative measure of population medians. Neither measure describes the actual amount that low income homes spend on heating costs. Understanding the actual fuel use of low income households is important for focusing resources and designing localised energy projects. This paper analyses real domestic fuel use of 447 households spread across rural and urban areas and income deciles in Scotland. The data illustrates a difference in spend between low income rural and urban households. The data used overcomes the difficulties in engaging low income households and experimental bias.

Introduction

It has recently been acknowledged that there is insufficient research on fuel poverty (Tirado Herrero 2012). How we define the fuel poor (Hills 2012) and how we identify them has been questioned (Fischbacher 2014; Moore 2012). Qualitative research has illustrated that poor households will limit their fuel use to reduce their bills, or alternatively burn fuel with no restraint until they are disconnected or switched to a prepayment meter and then self-disconnect (Brunner 2012). Nevertheless, there is insufficient evidence to describe the actual living conditions that the fuel poor

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experience (Majacen 2013; Brunner et al 2012; Moore 2012). Studies of domestic fuel use in the UK have tended to focus on middle income households (Baker 2007). This is because middle income households are more likely to engage in research and are less likely to lead chaotic lives. Low income households can be very difficult to engage and a lack of reliable, empirical data from this segment compromises our understanding (Dubois 2012) of the low income households' actual behaviour with respect to fuel use.

Background

In the UK, various definitions of 'fuel poverty' were developed through the 1970s and 1980s. However, the term was only formalised (and popularised) in the early 1990s by Brenda Boardman, in a PhD thesis later published as a book (Boardman 1991). Boardman identified fuel poverty as the situation where householders pay more than ten per cent of their incomes to heat their homes. Since Boardman's definition was first proposed it has been subject to debate and further studies. This has resulted in a diversification of the actual definition and the development of additional terms (Boardman et al 2005; Boardman 2012; Moore 2012; Price et al 2012).

There is currently no universal or European definition of fuel poverty. The level of deprivation, heating costs and heating requirements vary between states. The level and nature of micro level data also varies between different countries. So far investigations have relied on indirect measures and proxies to define the prevalence of fuel poverty (Healy 2002; Thomson 2013; Tirado Herrero 2010; Whyley 1997). In southern EU states cooling is as important as heating, and research in Greece has highlighted households unable to afford to cool their homes (Fokaides et al 2012). In the Baltic nations, it is not unusual for households to rely on additional heat sources (Tirado Herrero 2010). There is another aspect of fuel poverty in Eastern Bloc countries due to district heating systems installed under the former USSR programs. There, households can become trapped with an unaffordable heating bill, in poorly insulated buildings and a system with no controls (Tirado Herrero 2012). Some research has focused on the differences between modelled and actual energy use (Fokaides et al 2011; Majacen 2013). Other researchers have highlighted the lack of scientific reasoning for choosing 10 percent of income (Healy 2002). Boardman has also highlighted the failings of the

current definition to clearly define the group and in particular those that are considered vulnerable (Boardman 2010).

Fuel poverty

Fuel Poverty is influenced by three key drivers: fuel costs, housing conditions and household incomes. Correlations have been illustrated using averaged or modelled results between income and fuel expenditure (Dresner and Ekins 2004; Druckman 2008; Roberts 2008; White et al 2012). Behind the statistics on fuel poverty there is a significant portion of communities who live in abject poverty, in housing conditions many of us would not expect to find in developed countries (Green 2007; De Haro and Koslowski 2013). These are households at risk of being locked into a cycle of underachievement, ill health and unemployment. Many households are disenfranchised from their energy use through a lack of understanding of the systems and inability to operate their heating systems. Disenfranchisement from control has been identified as an alternative aspect of fuel poverty (Űrge-Vorsatz 2012).

The responsibility for fuel poverty is devolved to the Scottish Government.[2] Initially both the English, Welsh and Scottish governments adopted a similar definition for fuel poverty, however England has now adopted an alternative definition.[3] In Scotland a fuel poor household is defined as one which: "needs to spend more than 10 per cent of its income on all household fuel use" (Scottish Government 2002). In Scotland the above definition was primarily reported with the inclusion of Housing Benefit and Income Support but was also reported excluding these benefits. The definition of a satisfactory heating regime is the one recommended by the World Health Organisation which is used by the UK Department of Environment and Climate Change (DECC).

[2] The Scottish Government can set its own fuel poverty policy, but Scottish devolution means that in terms of the three causes of FP (energy prices, low incomes and energy efficiency of homes) the Scottish Parliament only has the power to regulate the energy efficiency of homes. Even in this area it is limited to taking measures on energy efficiency "other than by prohibition or regulation' (Scotland Act 1998, schedule 5, part 2, head D, 'Energy'). The regulation of the energy market, social security and employment remain 'reserved matters' over which the Scottish Parliament has no power (Scotland Act 1998, schedule 5, part 2, heads D 'Energy', F 'Social Security' and H 'Employment' respectively).

[3] The Hills Report (Hills, 2012) defines Fuel Poverty as a relative state in relation to population medians. Under this definition a household is in fuel poverty where: they have required fuel costs that are above average (the national median level); and, were they to spend that amount they would be left with a residual income below the official poverty line (DECC 2013b).

The Scottish definition includes a further clarification of a satisfactory heating regime for householders. These definitions are:

> *21° C in the living room and 18° C in other rooms for a period of 9 hours in every 24 (or 16 in 24 over the weekend); with two hours being in the morning and seven hours in the evening.*

Or for the elderly:

> *23° C in the living room and 18° C in other rooms, to be achieved for 16 hours in every 24* (Scottish Government 2002).

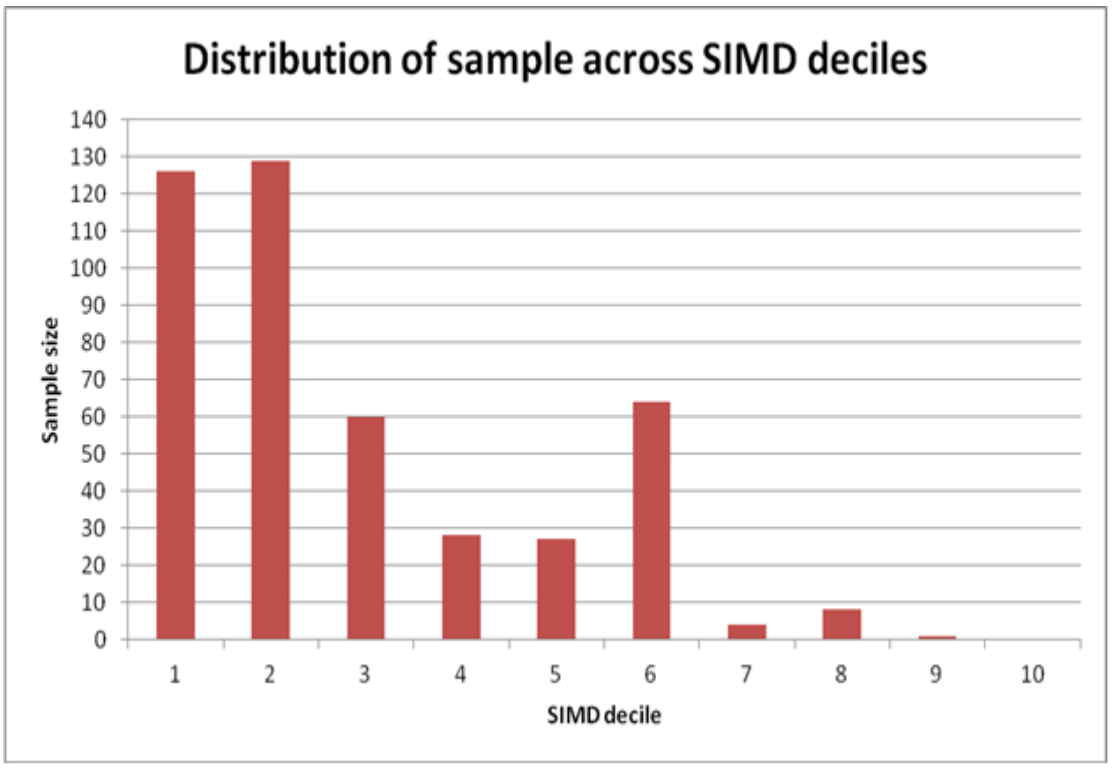
Methods and Materials

Data used for this report was made available from Renfrewshire Council, Scotland. The council area lies to the west of Glasgow City and is reported to have the lowest percent of its population in fuel poverty (Scottish Government 2012a). Its main urban and sub-urban areas are continuous with Glasgow which lies to the east. Renfrewshire is dominated by its main town, Paisley. To the west of this there are relatively remote rural areas. Although Renfrewshire is reported to have the lowest percent of its population in fuel poverty it is also currently home to the most deprived area of multiple deprivation in Scotland and is ranked seventh for the percent of its area within the 0-15% deprived areas out of thirty two local authorities in Scotland. Areas of multiple deprivation are reported in Scotland as Scottish Indices of Multiple Deprivation (SIMD).

Detailed analysis is based on actual gas use data from Renfrewshire Council housing stock from October 2011 to June 2012. The data was collected from gas bills for the households with gas central heating (CH) and all other reasonable energy efficient interventions. New gas boilers are all A-rated combination boilers. All households had standard wet meters (as opposed to pre-payment meters). With no direct contact with the residents this data objectively documents the actual fuel use of households. When new gas services and gas CH are installed into Renfrewshire Council properties the gas

supply is initially under council ownership until it is transferred to the tenant. During the period between CH installation and the transfer of ownership to the tenants, Renfrewshire Council received bills for the gas used. These are new gas CH installations without gas cookers. When the new CH systems are installed they are set to deliver a heating pattern which meets the adequate heating regime used in the Scottish Government's fuel poverty definition. The tenants are instructed on the control options for the entire system. Any variations in actual fuel spend therefore arise from the intervention by the householders. Over 1000 bills were collected. These bills include those based on estimated gas use and those from actual meter readings. Only the bills based on actual initial and subsequent meter readings were used in this report, reducing the population size to 447. All bills were from the same supplier and cover the period from 18 August 2011 to 26 June 2013. The bills were analysed in pounds per day. This is the metric to which the majority of households relate directly (Fell and King 2012). The data was collected from properties mostly in the lower SIMD deciles as is illustrated in Figure 1.

Figure 1: Sample size by SIMD deciles



Actual spend on heating of low income households

It is clear that for each decile there is a wide variety of daily spends from individual households, but it is also apparent from Figure 2 and Figure 3 that as the value of the income deciles increases the average spend of those deciles also increases. There appears to be a straight line relationship which is endorsed by the analysis of the fit of the data to $y=0.0876x+1.3307$ which generates $r^2=0.6118$.[4] Since a value of r^2 above 0.3 is considered to be a good indicator of a correlation, the conclusion from this data and analysis is that there is a good correlation between spend and income. Druckman (2008) reported a correlation between gas use and household income based on modelled data of $r^2=0.25$, $p<0.01$. Dresner and Etkins (2004) also reported a weaker correlation of $r^2=0.171$, from an analysis of the English House Condition Survey and 1999-2000 Family Expenditure Survey. The national data for England and Wales reported by DECC produces a stronger correlation of $r^2=0.8857$. The data used in this report shows a much higher correlation of fuel spend to income decile than these previous studies but below the DECC figures.

[4] r^2 is a measure of the goodness of fit of the actual data to a specified relationship between the factors examined. The value varies between 0 and 1.0 and the closer r^2 is to 1 the better the data fits the proposed relationship.

Figure 2: Box plot: daily spend on fuel by income decile

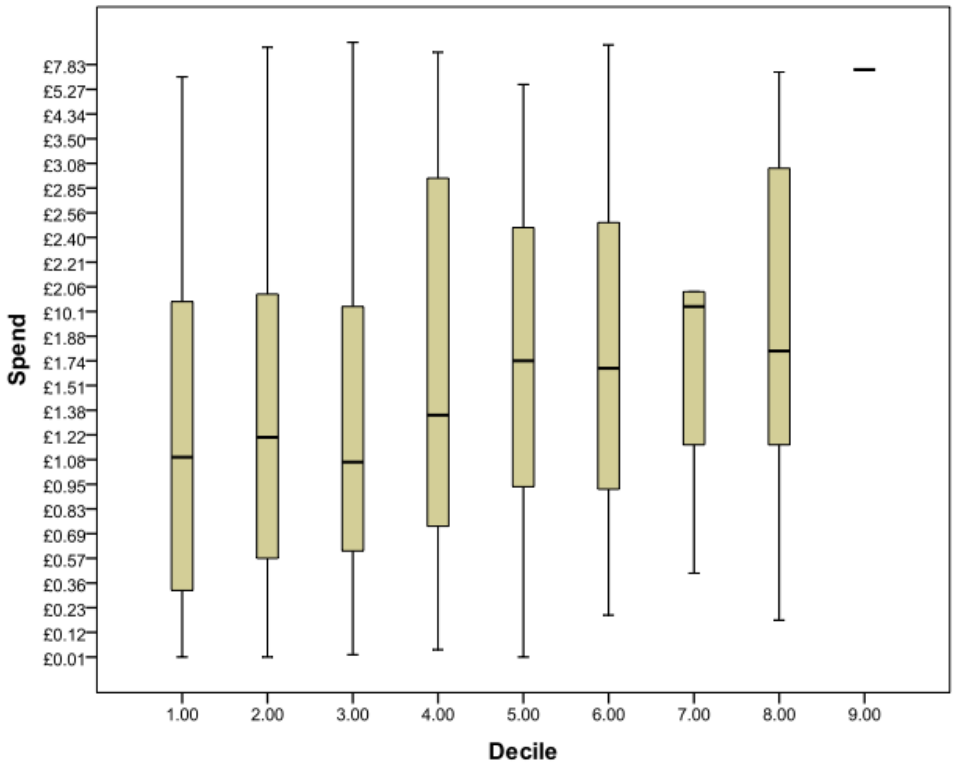
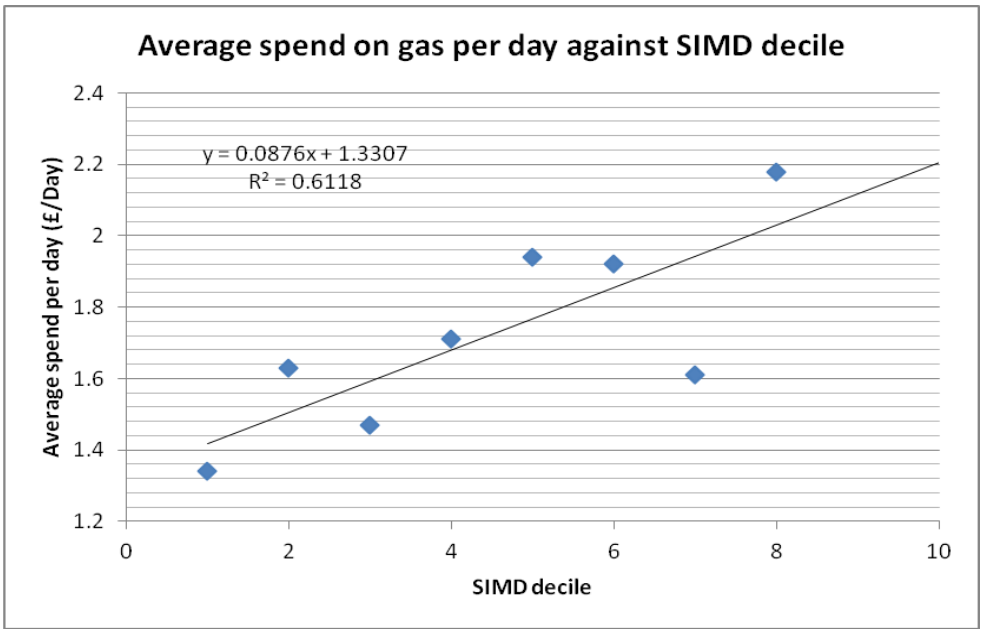


Figure 3: SIMD against average fuel spend on heating

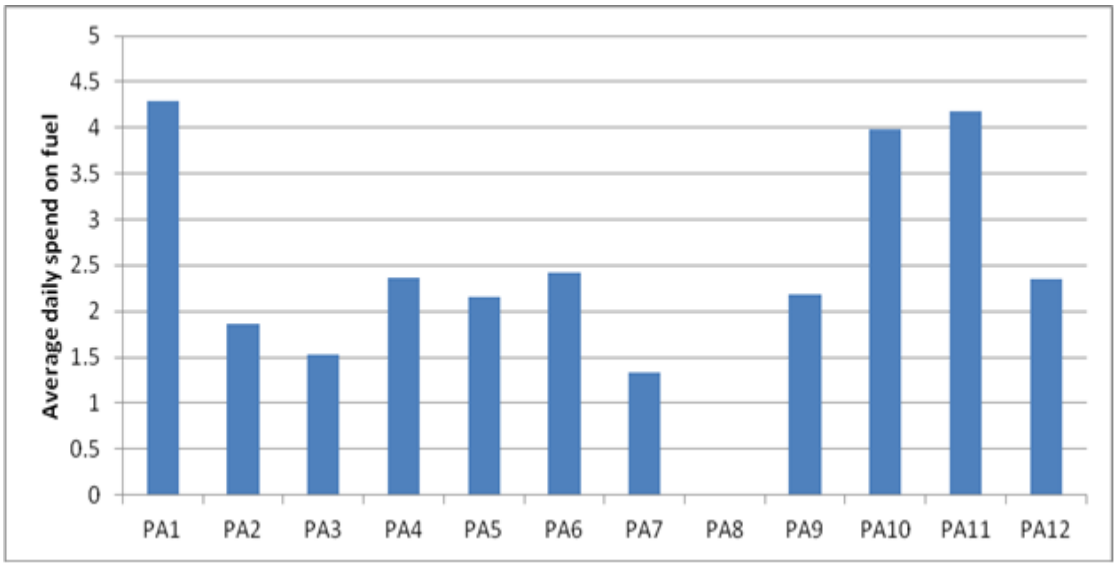


The very low fuel use of the lower SIMD decile households may also be a manifestation of those that 'feel fuel poor' as identified by Price (2012). That is those householders that perceive that they cannot afford the cost of heating their homes whether or not they are in actual fuel poverty. Therefore their self-imposed rationing is a response to how they perceive their own financial wellbeing.

Rural and Urban Fuel Poverty

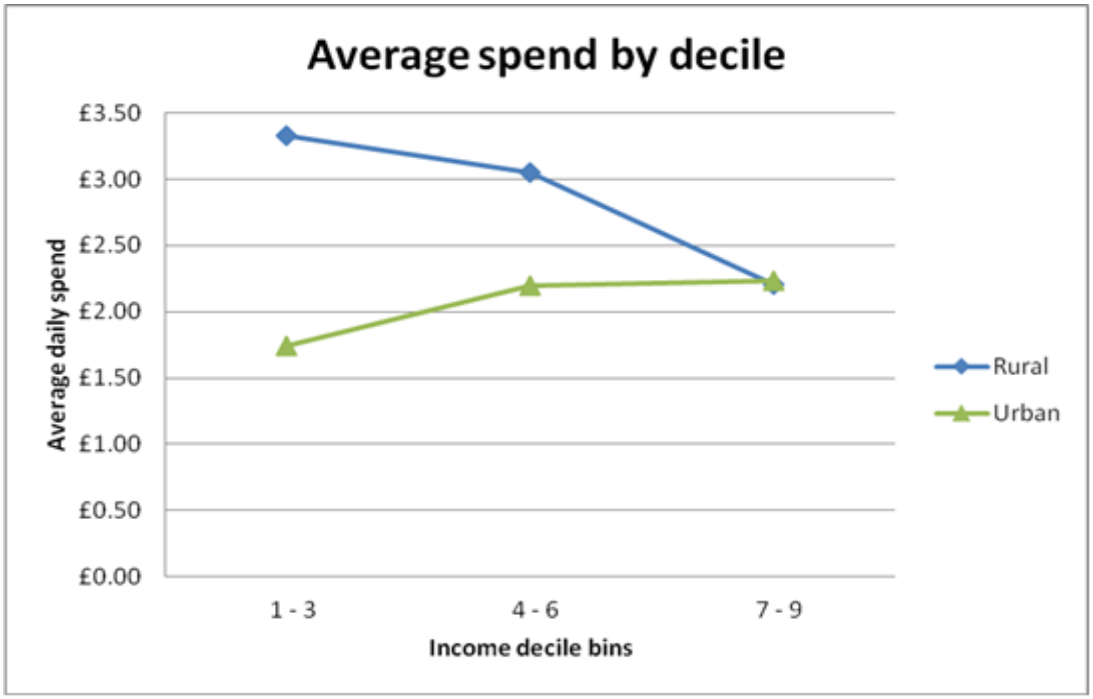
The data was studied by geographic distribution using postcode class levels. PA1 to PA9 are predominately urban postcodes and defined by the Scottish Government as large urban areas (Scottish Government 2012b). PA10 to PA12 are predominately rural, classified by the Scottish Government as Accessible Rural and Remote Rural (2012b). The sample sizes were too small to provide reliable data for individual deciles in the different categories; therefore they were summed in bins of three deciles.[5] The difference between average spend for rural and urban areas is shown in Figure 5 where it is apparent that the average spend for rural low income households differs from urban low income households.

Figure 4: Average daily fuel spend for postcodes



[5] Bins are bands within which data can be grouped when sample sizes are too small.

Figure 5: Average spend by decile bins



Since the data presented here was collected free from any influence on the householders it gives a highly accurate reflection of the gas use of low income households. It is assumed that the low income households in the sample are representative of the broad category. The differences between average rural and urban fuel spend were subject to a standard parametric statistical analysis in order to test if there was a statistically significant difference between the subpopulations.[6]

[6] The t-test undertaken in this analysis examines the average daily spends of the groups against each other and whether the differences are sufficient to conclude that they are different sub-populations.

Table 1: T-test analysis showing urban and rural spend on heating is equal

T test analysis				
	H_o: $\mu_{urban}=\mu_{rural}$			
	Assuming equal differences		*Assuming unequal differences*	
	Urban	*Rural*	*Urban*	*Rural*
Mean	1.8548	2.9723	1.8548	2.9723
Variance	6.2202	10.9308	6.2202	10.9308
Observations	402	45	402	45
Pooled Variance	6.6860			
Hypothesized Mean Difference	0		0	
Df	445		50	
t Stat	-2.7493		-2.1984	
P(T<=t) one-tail	0.0031		0.0163	
t Critical one-tail	1.6483		1.6759	
P(T<=t) two-tail	0.0062		0.0326	
t Critical two-tail	1.9653		2.0086	

The analysis disproves the null hypothesis that the amount spent on fuel in designated rural and urban areas is equal. P values assuming equal difference (P = 0.0062) and unequal differences (P = 0.0326) are both indicative of a statistically significant

difference.[7] The average spend of urban properties (£1.85 per day) is close to that of the UK average (£1.84 per day, DECC 2013).

Implications

Policy implications

This research has three main policy implications. The first and primary policy implication of the previous section is the unsuitability of SIMD as a proxy for fuel poverty.[8] SIMD tends to emphasise urban fuel poverty while rural fuel poverty is poorly captured, thus SIMD as a proxy for fuel poverty focuses investment in urban areas. It is undeniable that there are many urban fuel poor who are in direct need of any intervention possible. However, a focus on urban areas results in a neglect of the rural fuel poor. The money spent on urban areas is done at the expense of potential spend in rural areas where, as demonstrated, there are proportionally more fuel poor. Rural fuel poverty is harder to tackle since densities of rural fuel poverty are low (due to low housing density). The present authors have witnessed examples of rural homes which are in extreme fuel poverty but where the tenants maintain the exterior appearance of the properties. This may be an attempt to retain respect within tight-knit communities and to sustain a degree of dignity (Green 2007). This leads to deprivation for off-gas, low income, hard to heat homes in the countryside which are failed by current policies, as they are too difficult to address.

The second policy implication is that there is a higher fuel spend per housing unit in rural than urban areas. There may be multiple reasons for this, but it was demonstrated that the peri-urban properties form a continuous distribution with the spend from urban and rural properties. This would suggest that geographical location and exposure may be a primary factor. However, this would require further detailed investigations into these and other potentially influencing factors.

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[7] P values are a measure of the probability of the null hypothesis being true, that is that there is no difference between the two populations. The smaller the value the less likely the null hypothesis is true. Standard practice is $p \leq 0.05$ statistically significant and $p \leq 0.01$ is highly significant.

[8] The SIMD 0-15% band is used as a qualifying criterion for most projects which are aimed at addressing fuel poverty, for example ECO. As such it is used as a proxy for fuel poverty. The assumption is that these projects target the fuel poor based on that metric however poor SIMD tend to be concentrated in urban areas while rural areas are reported to have a higher portion of their populations in fuel poverty.

Furthermore, given our findings of low actual fuel use, it appears that there is very little carbon to be saved from the fuel poor. As illustrated here (especially Figure 5) and by Roberts (2008) the carbon density of households has a strong correlation to their SIMD decile rank. Since much of the fuel poverty eradication policies have a co-aim of carbon reduction, programmes that are not evenly spread across the SIMD deciles may not achieve the carbon savings they claim to make. An emphasis on low income households and poor performing SIMD deciles concentrates efforts in the homes where the least carbon is available to be saved. Efforts to maximise carbon savings should be focused on the upper SIMD deciles only.

Social and health implications

Under-heating in low income households (as shown above) means that many households are living in conditions which are detrimental to their health and wellbeing. The lack of heating will result in a build-up of mould which has been demonstrated to have a close response relationship with asthma (Norbäck et al 2013). Additional health impacts (cardio-pulmonary diseases, mental health, osteo and rheumatoid arthritis) have also been associated with or identified as exacerbated by poor housing conditions. Poor housing conditions and the inability to afford to maintain adequate heating regimes create a financial burden on the health and social welfare services. Current policies are failing to direct adequate resources toward the fuel poor through the design of the qualifying criteria - especially in rural areas.

Poorly heated properties are subject to a build-up of internal moisture resulting in condensation as well as being more prone to water ingress, especially solid wall properties with no vapour barriers. The build-up of moisture within the structure of a building will result in its slow degradation and potentially the development of wet rot within the woodwork. The most immediate elements that will suffer damage are the windows, where water is most likely to condense, along with kitchen and bathroom units where air flow is restricted. For the socially rented sector, this results in properties requiring major refits once they have become void. This has a direct financial impact on the landlords and an indirect impact by increasing the time that the properties remain unrented while refurbishment takes place. Only a policy aimed at delivering affordable

warmth standards would have any impact on this situation. The current policy emphasis on insulation upgrades and fuel switch to gas does not deliver affordable warmth standards and is therefore failing to address the core problem. Any programme which aims to provide affordable warmth will be significantly more expensive than existing programmes.[9]

Conclusion

Low income households are severely limiting their fuel use. This has significant impacts on the cost burden to society through the householders' compromised health and wellbeing, and the degradation of the quality of the housing stock. The restrictions in fuel use also demonstrate that the carbon emissions from low income households are significantly below the population average and any modelled predictions. As a result existing energy efficiency programmes are overstating the carbon savings they achieve. Fuel poverty is proportionately more significant in rural areas but fuel poverty programmes are failing to meet their needs as they focus efforts on urban areas where fuel poverty is more concentrated. Even when the same fuels are used the actual spend in rural properties is higher than in comparable urban homes. Unless these differences are taken into consideration when designing fuel poverty programmes the Scottish target of eliminating fuel poverty by 2016 will remain unattainable. There is a need for further research to define the differences between rural and urban fuel spend.

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[9] Affordable warmth is a term that has come into common usage in Scotland and throughout the UK. It differs from existing projects which are aimed at carbon saving and a unit cost of that carbon through schemes such as ECO. Affordable warmth aims to provide solutions which are affordable to the residents regardless of the costs or the carbon savings. As such affordable warmth solutions are more diverse than existing solutions and potentially much more expensive.

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